EXPLANATION OF PLATE XIII.

A.—Part of the upstream exposure of banded clay in Trapyard Creek. 10 cm. intervals are marked on the stick.

B.—The downstream clay exposure showing the irregular base of the clay horizon at this locality. Sand and grit derived from granite and occasional rock fragments constitute the section above and below the clay. A discontinuous sandy band occurs in the clay horizon. Banding is not as regular here as in the upstream exposure.

C.—Banded clay from the upstream locality (see A) showing alternations of fine and coarser bands. Note the graded bedding.

D.—A fragment from the base of the clay horizon at the downstream locality (see B) showing folds (outlined) due to slumping of the basal bands after deposition on an irregular surface. The material upon which the clays and silts were deposited has been caught up into the arches of the slump folds. The troughs of the folds are infilled with coarse quartz and felspar sand and mica flakes mixed with clay. Coarse silt, followed by finer silt and clay, deposited on a more level surface (marked by dashes) above the slumped horizon creates a local intraformational unconformity.

AUSTRALIAN RUST STUDIES. XIII.

Specialization of Uromyces phaseoli (Pers.) Wint. in Australia.

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(Plate xiv.)

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Synopsis.

Use has been made of a set of differentials from U.S.A. over a period of 12 years to determine physiologic races of *Uromyces phaseoli* (Pers.) Wint. in Australia. For many years races 2 and 17 as described by Harter and Zaumeyer were the only races found, but in recent years another race styled race 17A has become most important. It attacks the widely grown dwarf varieties which were resistant to the former races, and has almost completely superseded these latter.

Numerous varieties from many sources have been classified on the basis of their resistance to the 3 races. Most show susceptibility to all 3 races. Amongst those showing full resistance, the Western Australian variety "Westralia" is outstanding, and has been used as a parent in crosses designed mainly to give resistant dwarf types.

Several morphological aberrations are described.

Introduction.

Bean rust, caused by *Uromyces phaseoli* (Pers.) Wint., was first recorded in New South Wales in 1894 (Noble, Hynes, McCleery and Birmingham). Until recent years its damage was done to runner types like "Epicure", which were often ruined late in the season. Now dwarf varieties are heavily attacked as well, and this attack may come early in the season.

Control of the disease by spraying or dusting is probably uneconomic on a commercial scale: the use of resistant varieties offers the best method of control. In such breeding work it is essential that the life history, and especially details of the specialization of the pathogen, should be worked out if a sound programme is to be followed. Harter and Zaumeyer (1941) described 20 physiologic races in U.S.A., and Fisher (1952) has added 10 more races, using 2 additional varieties as differentials.

Life History.

To date the aecidial stage has not been recorded in Australia, although it has been sought. Efforts have been made to germinate teleutospores, but without success. These are formed freely, replacing uredospores, late in the season, and in nature may have germinated and produced the small aecidia which escaped detection on the early growth of the bean plants. Along the coastal area from Queensland to Victoria beans are grown all the year round, and it is probable that the uredospore stage persists all the time in one region or other. During the short time that these studies have been in progress, there has been no month of the year in which uredospore material has not been submitted for determination. Air-borne uredospores are probably responsible for initiating the epiphytotics that develop in commercial areas when weather conditions become favourable.

Physiologic Specialization.

In 1925 a series of determinations of rust reactions was made on the group of bean varieties brought from Cornell University and then in use for sorting out physiologic races of *Colletotrichum lindemuthianum*. The rust was collected on "Epicure" runner beans growing in a suburb of Sydney. At that time only runner beans showed rust attack.

The results obtained can now be compared with those given on the same set of varieties when inoculated with a race of the rust known to be r.17. In all cases there is agreement in respect of the resistance or susceptibility shown. It appears probable, therefore, that r.17 was present as far back as 1925.

Following upon the publication of the extensive studies on specialization of the rust in U.S.A. by Harter and Zaumeyer (1941), seed of the differentials they used was kindly supplied in 1941 by Dr. Zaumeyer, and at the commencement of 1942 a beginning was made with studies of Australian material.

Materials and Methods.

In general the procedure set out by Harter and Zaumeyer (1941) was followed. Marked differences were found in some cases between the reactions shown in the plant house in the summer as compared with the winter, although Wei (1937) reports that temperature variations between 16° and 28° C. did not change the type of reaction. A change from "4" to "7" reaction has not been uncommon here.

The notation used by Harter and Zaumeyer (1941) was adopted. In this, Grade 0 denotes immunity, and Grade 10 complete susceptibility, with the intervening grades linking these two extremes. Sometimes, and particularly in the work with commercial bean varieties, difficulty was experienced in determining with accuracy many of these intervening grades which vary with temperature fluctuations.

Collections of rusted material in the uredospore stage were dealt with in the plant house without delay: storage in the refrigerator seldom exceeded two weeks. Dundas (1949) reported that new races were produced by mutation in cold storage. Stock cultures from race determinations were stored on leaves dried out at room temperatures before going into the refrigerator. At a temperature of approximately 3° C. the spores remained viable for periods of 6 months. It was noted in some cases that spores after storage showed no germinations in hanging drop cultures, but nevertheless produced satisfactory infections when used to inoculate leaves of susceptible varieties.

Seedlings in 4-inch pots were used for inoculation at the stage when the primary leaves were fully expanded. After atomising with water, the spores were lightly rubbed over the surfaces, and the pots incubated for a period of 24 hours before being placed on the plant house benches. Two to three weeks were necessary for the reactions to develop.

Purity of Differential Varieties.

From the outset, the need for maintaining genetic purity of the differential varieties became apparent. Sowings of the original seed sent from U.S.A. led to the production of seedlings which showed marked differences between the pigmentation of the hypocotyl and cotyledons, as well as differences in the green colour of the first foliage leaves. This was especially noted in two of the differentials.

In the variety "White-seeded Kentucky Wonder Hybrid, No. 780", colour differences were noted and led to comparative work being done on single plant progenies. From sowings of typical seed of the variety, four typical single plants were taken, and from each family several single plants were grown on for progeny tests.

One family gave resistance ("1" or "2" reactions) throughout when tested with races 2 and 17. Homozygosity for green pigmentation was shown.

Two families showed the same double resistance throughout. In one of them, 2 of the 8 progenies were homozygous for the green and one homozygous for the purple pigmentation, while the remaining 5 progenies were heterozygous. In the second family, 5 of 11 progenies were homozygous for green and 2 for purple pigmentation, whilst the remaining 4 progenies were heterozygous.

The fourth family was susceptible ("8" or "9" reactions) to race 2 and resistant (reactions "1" or "2") to race 17 throughout. Two of the 7 progenies were homozygous for green and 2 for purple pigmentation, whilst the remaining 3 progenies were heterozygous.

In a second variety, "Bountiful No. 181", even stronger evidence of wide variability was found.

Again, sowings of typical U.S.A. seeds of the variety were made, and from this 7 typical single plants were taken and grown on. Progenies from each were tested as seedlings with the following results:

2 of them gave 7 progenies each, all showing susceptibility ("8" reaction) to each of the races 2 and 17.

2 of them gave 7 progenies each, all showing resistance ("1" or "2" reactions) to races 2 and 17.

3 were heterozygous:

1 gave 5 progenies, 2 giving r.2 = "9" and r.17 = "1" reactions, 3 giving r.2 = "3" and r.17 = "9" reactions.

1 gave 7 progenies, 2 giving r.2 = "9" and r.17 = "8" reactions, 2 giving r.2 = "8" and r.17 = "3" reactions, 3 giving r.2 = "2" and r.17 = "2" reactions.

1 gave 6 progenies, 4 giving r.2 = "8" and r.17 = "8" reactions, 1 giving r.2 = "8" and r.17 = "1" reactions, 1 giving r.2 = "1" and r.17 = "1" reactions.

Pigmentation, as well as rust reaction, was recorded throughout. Only one of the 7 families was homozygous for the green pigmentation: it was one of the 2 which were resistant throughout to races 2 and 17. The remaining 6 were heterozygous for the colour production. There was no correlation between the rust reactions and pigmentation.

In this same variety, still further proof of variability was found after race 17A was recorded.

An isolate giving the reactions of r.2 produced resistant ("2") reactions on one of the plants in a pot. It gave the same reaction to r.17. This and a typical susceptible plant in the pot were grown to maturity. They conformed to the morphological characteristics of the variety. The progeny were tested with all 3 races. Those of the resistant plant were resistant to r.2 and r.17 but susceptible to r.17A, whilst those of the susceptible parent showed susceptibility to all 3 races. The tests were carried on another generation in each of the families, and similar results obtained.

At the same time three other random single plants were taken and the progeny tested in the same way. Two of them gave the resistant reactions to r.2 and r.17 and susceptible reactions to r.17A, whilst the other plant gave susceptibility to all 3 races.

In these cases there was no evidence of morphological heterozygosity, and the origin of the variants is unknown.

No information was available as to where the seed had been grown in U.S.A., and nothing is therefore known about the likelihood of natural crossing taking place. But it is clear that this phenomenon must always be taken into account in work of this sort, and the strictest control of the parentage of varieties maintained.

Results of Race Determinations.

To date 3 races have been determined, two of them conforming to races 2 and 17 of Harter and Zaumeyer. The third differs markedly from r.17 in its capacity to attack dwarf "Wonder" varieties like "Canadian Wonder", "Wellington Wonder", "Tweed Wonder", "Hawkesbury Wonder", "Clarendon Wonder", "Richmond Wonder", and "Brown Beauty", and is designated r.17A. This follows the procedure used in the cereal rusts.

Typical reactions are set out in Table 1.

The results of the survey are set out in Tables 2 and 3.

It is seen that during the first part of the period—up till 1948—r.17 was present in 70% of the collections, r.2 accounting for the remaining 30%.

Of the 14 isolates of r.2, 10 came from Western Australia. In 8 of them, r.17 was also present. Similar mixing of races has occurred in N.S.W. collections. The other 4 were found in the Sydney metropolitan area on dwarf varieties producing tiny "3" reactions (Plate xiv).

TABLE 1.

Typical Reactions of Three Physiologic Races of Bean Rust on Varieties of Phaseolus vulgaris.*

Race No.	Differential Varieties.							
	U.S. No. 3.	No. 181.	No. 643.	No. 650.	No. 765.	No. 780.	No. 814.	"Wonder" Variety.
2	8	7	8	9	2	1	1	2
17	8	7	1	9	3	1	1	2
17A	8	7	1	9	3	1	1	9

* The first seven differentials are those used by Harter and Zaumeyer (1941). The additional one is essential for Australian determinations.

In 1948 a serious outbreak of rust in dwarf varieties like "Brown Beauty" and "Hawkesbury Wonder" was observed by the late Mr. R. D. Wilson of the N.S.W. Department of Agriculture: previously only tiny "3" grade pustules had been noted

TABLE 2.

Summary of the Number of Isolations of Physiologic Races of Uromyces phaseoli *Grouped according to Time of Collection*

Race No.	Year of Collection.												Totals.
	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	
2	—	1	11	1	1	—	3	3	—	—	—	—	20
17	4	2	13	8	3	3	11	7	4	3	1	—	59
17A	—	—	—	—	—	—	1	9	15	19	13	2	59
	4	3	24	9	4	3	15	19	19	22	14	2	138

on these beans. The occurrence of the two races together on "Hawkesbury Wonder" beans growing in the Sydney metropolitan area is shown in Plate xiv.

The rust on the dwarf beans proved to be a "new" physiologic race. Of the isolates examined since its appearance, r.17A has been present in 64%, r.17 in 29%, and r.2

TABLE 3.

Frequency of Occurrence of Races of Uromyces phaseoli *Grouped according to Source of the Collections Studied.*

Race No.	Source of Material Examined.				Totals.
	A.C.T.	N.S.W.	Q.	W.A.	
2	—	9	1	10	20
17	—	29	4	26	59
17A	1	31	6	21	59
	1	69	11	57	138